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How insects deploy their wings

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During their final transformation, insects emerge from the pupal case and within a few minutes, they deploy their wings for the very first time. Wings expand from a compact, pleated structure, to form a planar, rigid wing blade that allows flight. The deployment is powered by an increase of internal pressure, and by the subsequent injection of hemolymph into the deployable wing structure.

To study this phenomenon, we turned to the fruit fly *Drosophila Melanogaster*. We first characterized the unfolding kinematics at the organ scale. Using optical microscopy, we analyzed the shape of the initial origami-like folded wing, and its relationship to the final network of veins. We then imaged wing sections using transmitted electron microscopy to study the morphological evolution of the wing cross-section, at different stages of expansion. We used micro-tomography to gain insight into the 3D structure of the folded wings, as well as their internal structure. We found that beyond the mere unfolding of the macroscopic folds, wing deployment also involves an expansion of cell surface area and the unfolding of microscopic folds of the cuticle enveloping the wing, leading to a two-fold wing size increase. We complemented these observations with mechanical measurements of the wing elasticity, characterization of the hemolymph flow, and scaling analyses, building an integrated understanding of how the pressure increase enables consistent wing deployment through the fluid-structure interaction.

This work combines morphometric, kinematic, and mechanical analyses to provide insight into a fascinating, yet largely overlooked phenomenon: how insects deploy their wings.

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